

CLAIMS

What is claimed is:

1. A method for allocating communication channels for handoff in a first base station having a communication link with active mobile stations located in a handoff area of the first base station and a second base station, the method comprising:
  - (a) constructing a channel convertible set including communication channels for active mobile stations moving in a direction away from the first base station;
  - 10 (b) receiving a handoff request from a requesting mobile station having a communication link with the second base station;
  - (c) determining whether a free channel is available for the handoff request; and
  - 15 (d) if a free channel is not available for the handoff request, allocating one of the communication channels in the channel convertible set to the handoff request.
2. The method of claim 1 wherein constructing a channel convertible set includes determining whether the active mobile stations are moving in a direction away from the first base station.
- 20 3. The method of claim 2 wherein determining whether the active mobile stations are moving in a direction away from the first base station includes determining whether the signal strength of the communication link between the active mobile stations and first base station has decreased over a period of time.

- 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042 1043 1044 10



9. The method of claim 1 wherein the communication channels included in the channel convertible set are associated with mobile stations requesting handoff to the second base station.
10. The method of claim 9 wherein the communication channels included in the channel convertible set are associated with mobile stations each having a second communication channel with the second base station, wherein the signal strength of the second communication channel is greater than the signal strength of the communication channel with the first base station.
11. The method of claim 1 wherein the communication channels included in the channel convertible set are associated with mobile stations each having a second communication channel with the second base station, wherein the signal strength of the second communication channel is greater than the signal strength of the communication channel with the first base station.
12. The method of claim 1 wherein a set of communication channels included in the channel convertible set are associated with mobile stations each having a communication channel with the second base station and the mobile stations move from a location wherein the signal strength of the communication channel with the first base station is greater than the communication channel with the second base station to a location wherein the signal strength of the communication channel with the second base station is greater than the communication channel with the first base station.

13. The method of claim 1 wherein the first base station is operable in a Code Division Multiple Access communication system.
14. The method of claim 1 wherein the handoff process is soft handoff.
15. The method of claim 14 wherein the first base station has an initial  
5 number of soft guard channels reserved for mobile stations requesting a communication link in the handoff area.
16. The method of claim 15 further comprising:
  - (a) determining the number of communication channels in the channel convertible set; and
  - 10 (b) reducing the number of soft guard channels based on the number of communication channels in the channel convertible set.
17. The method of claim 1 wherein allocating one of the communication channels in the channel convertible set includes:
  - (a) determining whether the requesting mobile station is moving in a  
15 direction towards the first base station; and
  - (b) if the requesting mobile station is moving in a direction towards the first base station, allocating a channel in the channel convertible set to the requesting mobile station.
18. The method of claim 1 wherein allocating one of the communication  
20 channels in the channel convertible set includes:
  - (a) determining whether the requesting mobile station is stationary with respect to the first base station; and
  - (b) if the requesting mobile station is stationary with respect to the first  
25 base station, allocating a channel in the channel convertible set to the requesting mobile station.



19. A method for allocating a communication channel of a first base station from a first mobile station located in a handoff area and having an active communication link with the first base station to a second mobile station requesting handoff, the method comprising:
- 5 (a) estimating the mobility of the first mobile station with respect to the first base station;
- (b) receiving a handoff request from the second mobile station; and
- (c) in response to determining that the first mobile station is moving in a direction away from the first base station, converting the
- 10 communication channel from the first mobile station to the second mobile station.
20. The method of claim 19 wherein determining that the first mobile station is moving in a direction away from the first base station includes determining whether the signal strength of the active communication link
- 15 between the first mobile station and the base station has decreased over a period of time.
21. The method of claim 20 wherein determining whether the first mobile station is moving in a direction away from the first base station includes determining whether the signal strength of the communication link
- 20 between the active mobile station and a second base station has increased over a period of time.
22. The method of claim 19 wherein the communication channel is converted only in response to determining the first mobile station is stationary with respect to the first base station.



23. The method of claim 22 wherein determining the first mobile station is stationary with respect to the first base station includes determining whether the signal strength of the active communication link between the first mobile station and the first base station is substantially the same over a period of time.
24. The method of claim 22 wherein determining whether the first mobile station is stationary includes determining whether the signal strength of the communication link between the first mobile station and a second base station are substantially the same over a period of time.
25. The method of claim 22 wherein determining that the first mobile station is moving in a direction away from the first base station further includes determining whether the first mobile station has a second communication channel with a second base station, wherein the signal strength of the second communication channel is greater than the signal strength of the communication channel with the first base station.
26. The method of claim 19 wherein determining that the first mobile station is moving in a direction away from the first base station further includes determining whether the first mobile station is requesting handoff to a second base station.
27. The method of claim 26 wherein determining that the first mobile station is moving in a direction away from the first base station further includes determining whether the first mobile station has a second communication channel with the second base station, wherein the signal strength of the second communication channel is greater than the signal strength of the communication channel with the first base station.

28. The method of claim 19 wherein determining that the first mobile station is moving in a direction away from the first base station further includes determining whether the first mobile station has a second communication channel with a second base station, wherein the signal strength of the second communication channel is greater than the signal strength of the communication channel with the first base station.
29. The method of claim 19 wherein determining that the first mobile station is moving in a direction away from the first base station further includes determining whether the first mobile station has a communication channel with a second base station and the first mobile station moves from a location where the signal strength of a communication channel with the first base station is greater than the signal strength of a communication channel with a second base station to a location where the signal strength of the communication channel with the second base station is greater than the signal strength of the communication channel with the first base station.
30. The method of claim 19 wherein the first base station is operated in a Code Division Multiple Access communication system.
31. The method of claim 19 wherein converting the communication channel to the second mobile station includes:
- (a) determining whether the second mobile station is moving in a direction towards the first base station; and
  - (b) if the second mobile station is moving in a direction towards the first base station, converting the communication channel from the first mobile station to the second mobile station.



32. A method for estimating the mobility of a mobile station with respect to a first base station, the method comprising:
- (a) receiving a signal including an indication of signal strength between the first base station and the mobile station;
  - 5 (b) determining whether the signal strength changes over a period of time; and
  - (c) if the signal strength changes over the period of time, determining that the mobile station is moving in a direction with respect to the first base station.
- 10 33. The method of claim 32 further comprising:
- (a) determining whether the signal strength increases over a period of time; and
  - (b) if the signal strength increases over a period of time, reporting that the mobile station is moving in a direction towards the first base station.
- 15 34. The method of claim 32 further comprising:
- (a) receiving a second signal including an indication of signal strength between a second base station and the mobile station;
  - (b) determining whether the signal strength between the first base station and the mobile station increases over a period of time;
  - 20 (c) determining whether the signal strength between the second base station and the mobile station decreases over a period of time;
  - (d) if the signal strength between the first base station and the mobile station increases over a period of time and the signal strength between the second base station and the mobile station decreases
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over a period of time, reporting that the mobile station is moving in a direction towards the first base station.

35. The method of claim 32 further comprising;

- (a) determining whether the signal strength decreases over a period of time; and
- (b) if the signal strength decreases over a period of time, reporting that the mobile station is moving in a direction away from the base station.

36. The method of claim 32 further comprising:

- (a) receiving a second signal including an indication of signal strength between a second base station and the mobile station;
- (b) determining whether the signal strength between the first base station and the mobile station decreases over a period of time;
- (c) determining whether the signal strength between the second base station and the mobile station increases over a period of time;
- (d) if the signal strength between the first base station and the mobile station decreases over a period of time and the signal strength between the second base station and the mobile station increases over a period of time, reporting that the mobile station is moving in a direction away from the first base station.

37. The method of claim 32 further comprising;

- (a) determining whether the signal strength remains substantially the same over a period of time; and





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- (c) modeling channel holding time using an exponential distribution with mean  $\mu_c^{-1}$ ;
- (d) generating a stochastic reward net model including a first station representing the normal area of a cell, a second station representing a set of calls without a channel convertible set, a third station representing a set of calls with a channel convertible set, and a fourth station representing a queue for handoff calls;
- (e) applying Markovian analysis to the stochastic reward net to determine a handoff call dropping probability; and
- 10 (f) designing mobile communication handoff call resources based on the call handoff call and dropping probability.
40. A system for allocating communication channels in a mobile communications network, the system comprising:
- 15 (a) a mobility estimator for estimating the relative mobility of mobile stations with respect to a base station;
- (b) a channel convertible set manager for generating a channel convertible set including communication channels for active mobile stations that are determined to be moving away from or stationary with respect to the base station based on mobility estimates generated by the mobility estimator; and
- 20 (c) a channel allocator for receiving requests for handoff calls and for allocating channels from the channel convertible set for the handoff calls.

41. The system of claim 40 wherein the mobility estimator estimates the relative mobility of the mobile stations based on pilot strength measurement messages received from the mobile stations.
42. The system of claim 41 wherein the mobility estimator determines that a mobile station is moving away from the base station when the pilot strength measurement messages indicate that pilot signal strength is decreasing over time.
43. The system of claim 41 wherein the mobility estimator determines that a mobile station is stationary with respect to the base station when the pilot strength measurement messages indicate that pilot signal strength remains within a predetermined range within a period of time.
44. The system of claim 40 wherein the channel convertible set manager adds communication channels to the channel convertible set based on the mobility estimates.
45. The system of claim 40 wherein the channel allocator determines whether free channels are available for handoff calls and, in response to determining that no free channels are available, allocates a channel from the channel convertible set.
46. The system of claim 40 wherein the channel allocator maintains a set of soft guard channels reserved for handoff requests and reduces the number of soft guard channels based on the number of channels in the channel convertible set.
47. The system of claim 40 wherein elements (a) – (c) are located in a base station.

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